

***Taygete sphecophila* (Meyrick) (Lepidoptera; Autostichidae): redescription of the adult, description of the larva and pupa, and impact on *Polistes* wasps (Hymenoptera; Vespidae) nests in the Galapagos Islands**

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***Taygete sphecophila* (Meyrick) (Lepidoptera; Autostichidae): redescription of the adult, description of the larva and pupa, and impact on *Polistes* wasps (Hymenoptera; Vespidae) nests in the Galapagos Islands.**

- *Taygete sphecophila* (Meyrick) (Lepidoptera; Autostichidae) is reported on the Galapagos Islands. The morphology of the moth, larva, and pupa are described and illustrated in details. Part of the mitochondrial DNA was sequenced and made available on GenBank. The incidence of predation by *T. sphecophila* on nests of *Polistes versicolor* Olivier (Hymenoptera; Vespidae) was measured in four different vegetation zones of Floreana and Santa Cruz Islands. The percentages of infested nests varied greatly (from 13.9% to 66.7% on Floreana and from 20.0 to 100% on Santa Cruz) and no clear ecological trends could be ascertained.

**Keywords:** Micro moths - Autostichidae - *Taygete* - *Polistes* - Galapagos Islands - mitochondrial DNA - larval predation - morphology - ecology.

INTRODUCTION

*Taygete* was described by Chambers (1873) to accommodate *Evagora difficilisella* Chambers, 1872 (Nye & Fletcher, 1991). The latter name proved to be a synonym of *T. attributella* (Walker, 1864). The genus appears to be restricted to the

New World. Becker (1984) lists 13 names in this genus for the Neotropical fauna while Hodges (1983) lists six species for the North American fauna, including five that are stated to be misplaced in this genus. BL's examination of the type specimens of the Neotropical species at the Natural History Museum, London, points to the possibility that only *T. sphecephila* (Meyrick, 1936) is congeneric with *T. attributella* in this region. However, the types of *Epithectis consociata* Meyrick, *E. notospila* Meyrick, and *E. altivola* Meyrick have lost their abdomen and cannot be assigned to genus, and the type of *E. lasciva* Walsingham, deposited in the USNM, Washington, could not be found.

*Taygete* Chambers was considered to belong to the Gelechiidae until Landry (2002) moved it to the Autostichidae, Symmocinae sensu Hodges (1998). *Taygete sphecephila* was described from three specimens bred in Trinidad from "bottom of cells of the Hymenopteron *Polistes canadensis*" (Meyrick, 1936). The moth and male genitalia were later illustrated with black and white photography by Clarke (1969). On the Galapagos Islands moths of *T. sphecephila* were first collected in 1989 by BL, but the species probably arrived earlier within nests of *Polistes versicolor* Olivier (Vespidae).

The purposes of this paper are to redescribe and illustrate the moth of *T. sphecephila*, to describe and illustrate the larva and pupa, to present part of its mitochondrial DNA, and to report on a few aspects of its biology, particularly with regard to the incidence of damage to *P. versicolor* nests by larvae.

## MATERIAL AND METHODS

Moths of *T. sphecephila* were first collected at night with a mercury vapor light set in front of a white sheet and powered by a small generator, and with an ultra-violet lamp powered by a battery. Other adult specimens were reared from contained nests of *Polistes versicolor*. Immature stages were found by dissecting *Polistes* nests and by exposing them to the sun, which causes larvae to exit nests and run away from them (Fig. 2).

Specimens are deposited in the Charles Darwin Research Station (CDRS), Santa Cruz, Galapagos, Ecuador; the Canadian national Collection of Insects (CNC), Ottawa, Ontario, Canada; the United States National Museum of Natural History, Washington, D.C., U.S.A. (USNM), and the Muséum d'histoire naturelle (MHNG), Geneva, Switzerland.

For the study of specimens using electron microscopy, larvae and pupae were first rinsed several times in water, cleaned in 10% EtOH with a camel hairbrush, and then dehydrated in EtOH as follows: 10% EtOH for 15 minutes, 20% for 15 minutes, 40% for 15 minutes, 70% for 1/2 hour, 90% for 1/2 hour, and 100% for 1/2 hour each in two separate baths. After dehydration, specimens were critical-point dried using a Tousimis critical point dryer, mounted on stubs, and coated with gold-palladium (40-60%) using a Cressington sputter coater. The ultrastructure of the larvae and pupa was studied with an Amray scanning electron microscope.

Gross morphological observations and measurements of the larvae and pupae were made using a dissecting microscope (reflected light) with a calibrated micrometer.



FIGS 1-2

1, *Taygete sphecophila*, female; 2, part of an abandoned nest of *Polistes versicolor* exposed to the sun with at least 8 larvae of *Taygete sphecophila* exiting from it.

Maps of the larval chaetotaxy were initially drawn using a WILD dissecting microscope with a camera lucida attachment. Terminology for chaetotaxy follows Stehr (1987).



In order to certify that the larvae corresponded to the adults found we sequenced a fragment of the mitochondrial gene Cytochrome oxidase I (COI) of both. Whole genomic DNA was extracted using the Nucleospin kit (Macherey-Nagel). The COI gene was amplified by PCR with two primers: k698 (5'-TACAATTTATCGCC-TAAACTTCAGCC-3'), and Pat2 (5'-TCCATTACATATAATCTGCCATATTAG-3'). The thermal profile started with an initial denaturation at 95°C for 5 min, followed by 35 cycles at 94°C for 30 s, 47°C for 30 s, and 72°C for 1 min 30 s, and a final step at 72°C for 10 min. The purified PCR product was sequenced in both directions using fluorescent dye terminators in an ABI 377 automated sequencer. The sequence is available from GenBank (Accession No. DQ309437).

In order to determine the distribution and the density of *Taygete sphecophila* as predator on *Polistes versicolor* nests, several study sites were selected in four of the vegetation zones of Santa Cruz and Floreana Islands. In each vegetation zone a series of quadrats of 10 m x 10 m were made at random, and the number of active and inactive nests of *Polistes versicolor* were counted. The delimitation of vegetation zones was based on vegetation composition (Wiggins & Porter, 1971). Nests were found by visually searching the study sites. In addition, nests found in and near Puerto Ayora, a small town located on the littoral and arid zones on the south coast of Santa Cruz Island, were included in the study. The presence of *T. sphecophila* in *Polistes* nests was determined by the presence of little holes on the back of the nests (Fig. 2) and distinctive breaches on the capped cells normally occupied by wasp pupae. In 1999, nests of *Polistes versicolor* were monitored weekly in the area of Puerto Ayora, and nests that were abandoned after being infested by *T. sphecophila* were collected during that period of time. Some adults of *T. sphecophila* that emerged from these nests were preserved dry for taxonomic identification. The ecological observations were made between April and August 1999, February and April 2002 and 2003 on Santa Cruz Island, and between April and August 1999 on Floreana Island. To test for ecological or insular trends in the frequency of parasitism of *P. versicolor* nests by *T. sphecophila*, we performed a G-test for goodness of fit (Sokal & Rohlf, 1995) on each island dataset using the proportion of *P. versicolor* nests in a given zone to infer the expected frequency of parasitism by *T. sphecophila*.

## TAXONOMIC TREATMENT

### *Taygete sphecophila* (Meyrick)

*Epithectis sphecophila* Meyrick, 1936: 624; Gaede, 1937: 113; Clarke, 1955: 290; Clarke, 1969: 63, pl. 31 figs 4-4b; Makino, 1985: 25; Yamane, 1996: 85.

*Taygete sphecophila* (Meyrick); Becker, 1984: 47; Landry, 1999: 68; Landry, 2002: 818-819.

MATERIAL EXAMINED FOR MORPHOLOGICAL WORK: Moths (13 specimens from the Galapagos Islands, Ecuador): SANTA CRUZ: 1 ♀, C[harles] D[arwin] R[esearch] S[tation], arid zone, 19.i.1989, M[ercury] V[apor] L[amp] (B. Landry); 4 ♀ (two dissected with genitalia on slides CNC MIC 4586 & BL 1196, the latter with right wings on slide BL 1313), CDRS, arid zone, 3.ii.1989, MVL (B. Landry); 2 ♂ (one dissected, slide BL 1126), Barranco, ex larva en nido *Polistes versicolor*, 8.ii.1999 (L. Roque, No. 99.20); 1 ♀, NNW Bella Vista, GPS: 225 m elev., S 00° 41.293', W 090° 19.665', 18.ii.2005, u[ltra] v[iolet] l[ight] (B. Landry, P. Schmitz); 1 ♀ (dissected, slide BL 1195), 2 km W Bella Vista, 27.ii.1989, MVL (B. Landry); 1 ♀, casa L. Roque-Albelo & V. Cruz, GPS: 137 m elev., S 00° 42.595', W 090° 19.196', 27.ii.2005, uvl (B.

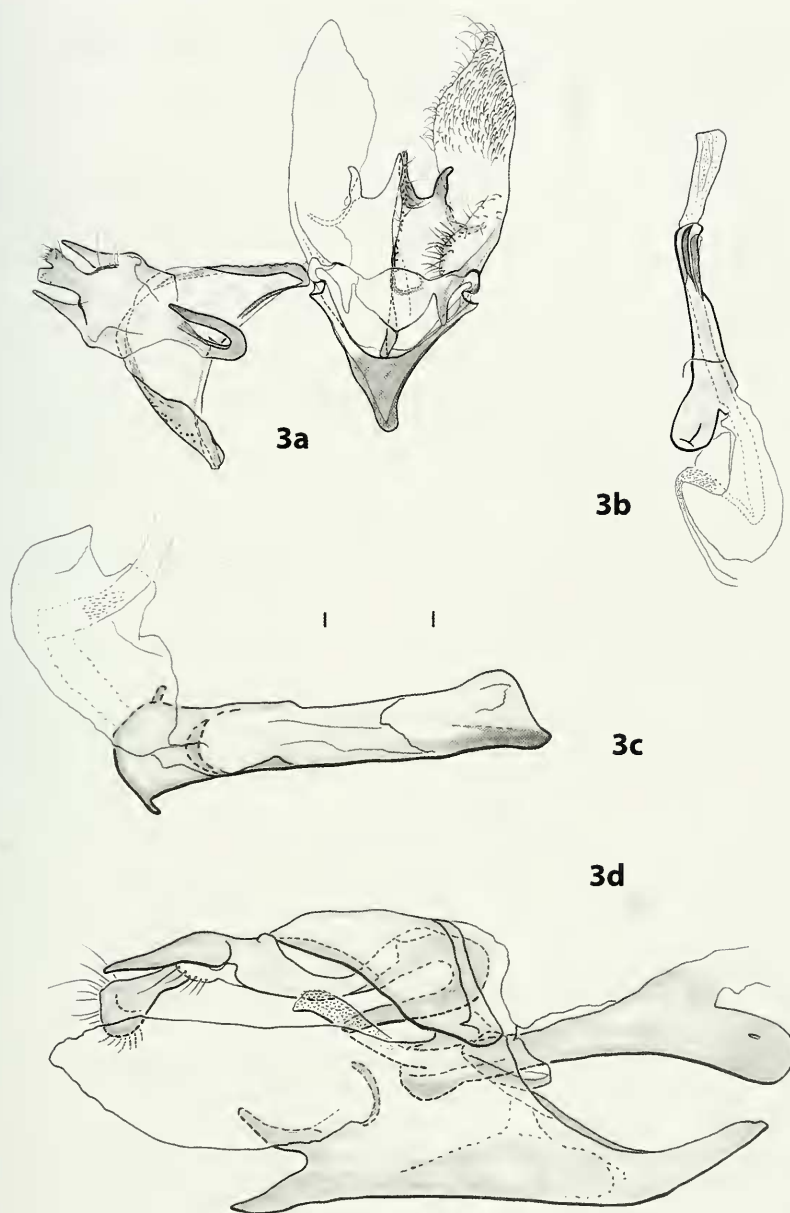


FIG. 3

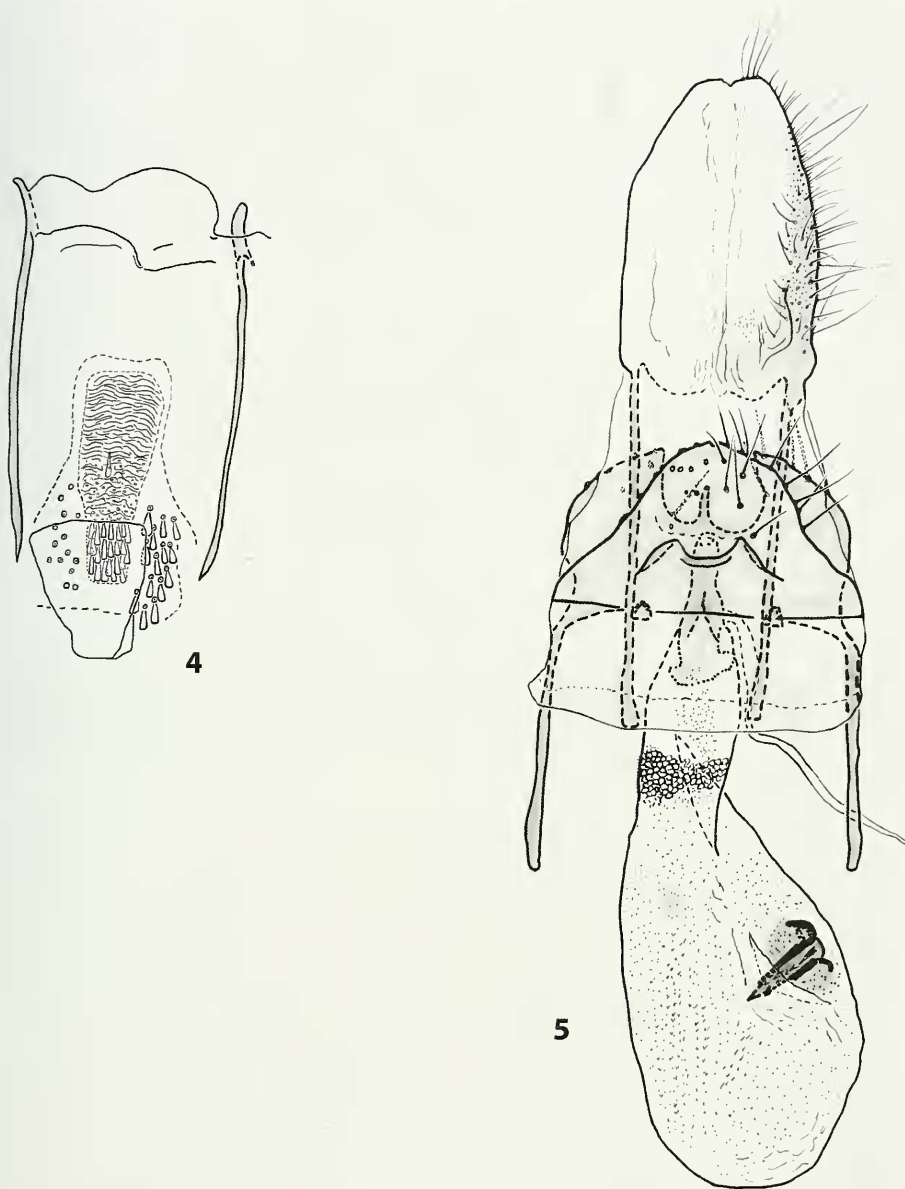
*Taygete sphecophila*, male genitalia (sizes not proportionate). 3a, dorsal view of valvae + vinculum + juxta and ventral view of tegumen + uncus + gnathos detached on right side and spread on left side, phallus removed, setae shown on right side only; 3b, side view of phallus with vesica everted; 3c, dorsal view of phallus, vesica inverted, scale = 0.1 mm; 3d, lateral view of whole genitalia.

Landry); 2 ♂ (dissected, slides BL 1208 & 1209), émergé d'un nid de Polistes, 1999 (C. Parent). SAN CRISTOBAL: 1 ♂, antiguo botadero, ca. 4 km SE P[uer]to Baquerizo, GPS: 169 m elev., S 00° 54.800', W 089° 34.574', 22.ii.2005, uvl (B. Landry).

Larvae (166 specimens) and pupae (10 specimens) collected on Santa Cruz by P. Schmitz in 2004 and 2005.

**DIAGNOSIS:** The presence in males of this species of a corematal organ at the base of the abdomen (Fig. 4) and a trifurcated uncus (Fig. 3a) are excellent diagnostic features with regards to the rest of the Galapagos fauna. Males of *Galagete* Landry are the only other Galapagos moths to share a corematal organ, but their uncus is made of a single projection. In females the shape of segment VIII (Fig. 5), especially dorsally, will separate *T. sphecephila* from any other species in the Galapagos and probably the rest of its range. On the archipelago, some species of *Galagete* Landry (2002) or Gelechiidae may appear superficially similar, especially because they share a similarly shaped hindwing, a similar wingspan, upturned labial palpi, and scales on the proboscis basally, but the forewing markings of *T. sphecephila* (Fig. 1) are unique among these groups.

**REDESCRIPTION:** General appearance of moth greyish brown with dark brown markings on forewing (Fig. 1); scales usually dark brown at their base and paler apically. Head scales longer laterally and directed medially and ventrally, except on occiput, directed medially and dorsally. Ocellus and chaetosema absent. Labial palpus gently curving upward, darker brown laterally than medially, with white rings of scales mostly at apex of segments; segments II and III shorter together than segment I. Antenna mostly greyish brown, darker brown toward base; flagellomeres in both sexes simple and with erect scales ventrally from about middle of flagellum. Thorax concolorous with head, sometimes darker brown at base. Foreleg mostly dark brown, with beige scales at apex of tarsomere I and on all of tarsomere V. Midleg mostly dark brown laterally, with paler scales at apex of tarsomeres I and II, and on all of tarsomere V, uniformly beige medially on femur and tibia, also with short tuft of dark brown scales dorsally on basal half of tibia. Hindleg paler than other legs, with some dark brown laterally on femur and tibia, mostly dark brown on tibial spines and at base of tarsomeres I-IV, also with tuft of long dirty white scales on dorsal margin of tibia. Wingspan: 7.5-9.0 mm. Forewing mostly greyish brown, with three dark brown triangular markings on costa, largest marking at base, reaching inner margin, smallest sub-medially situated, barely reaching cell, third marking large, reaching middle of wing; with dark brown scaling also at apex and as 1-3 small patches of 10 scales or less below postmedian costal marking; also with variable amounts of yellowish-orange to rusty-brown scales usually within basal dark brown marking, below postmedian marking, and toward apex; fringe dark brown at apex, more greyish brown elsewhere. Hindwing greyish brown without markings, with concolorous fringe. Wing venation (based on slide BL 1313, female) (Fig. 6): Forewing Sc to about 2/5 wing length; R1 from about middle of cell; R2 and R3 separate, both from before upper angle of cell; R4, R5, and M1 from upper angle of cell, connected, R4 and R5 directed toward costa before apex, M1 directed toward outer margin below apex; M2 and M3 separate, M2 from lower angle of cell, M3 from shortly before lower angle of cell; CuA1 and CuA2 separate, both from shortly before lower angle of cell; CuP absent; cell a little more than half



FIGS 4-5

*Taygete sphecophila*. 4, ventral view of first abdominal segment; 5, ventral view of female genitalia, setae shown on right side only.

wing length; A1 and A2 joined at about  $1/5$  their lengths. Female forewing retinaculum consisting of anteriorly directed scales at base of cubital stem and posteriorly directed scales at base of Sc. Hindwing Sc closely following costa, reaching it at about  $3/5$  wing length; Rs connected with M1 after upper angle of cell, Rs reaching costa at about  $4/5$



wing length, M1 directed toward apex; M2 from slightly above lower angle of cell, reaching outer margin below middle; M3 and CuA1 connected for about 1/2 their lengths after lower angle of cell, M3 to tornus, CuA1 to inner margin shortly before tornus; CuA2 from about 2/3 cell to inner margin at 7/10; CuP and anal veins indistinct; apex distinctly produced; outer margin distinctly concave; female frenulum with 2 acanthae. Abdomen dorsally mostly dark greyish brown, with dirty white scales at apex of all segments except last; ventrally dark brown on each side of large dirty white band except for last segment, mostly concolorous, greyish brown; male first abdominal segment (Fig. 4) ventrally with an invaginated pouch containing a membranous structure bearing scales (see Note below).

Male genitalia (Fig. 3). Uncus moderately long, with pair of fixed lateral, pointed and gently tapering glabrous projections; also with movable median projection, slightly longer than lateral projections, enlarged at apex and bifid, with each end bulbous and setose, also slightly setose at base laterally. Gnathos a long curved rod pointing posteriorly, apically more heavily sclerotized, tapered, glabrous, and rounded. Tegumen broad medially, with moderately narrow pedunculi. Valva with unsclerotized setose cucullus, tapering, rounded apically, with slightly sclerotized setose ridge at base on inner side, also with medium sized apodemes directed anteriorly from base of costa; sacculus with pair of short, narrow, setose, and apically rounded projections, dorsal projection curved and directed dorsally, ventral one straight and directed posteriorly. Vinculum narrow, slightly projected anteriorly and upturned. Juxta poorly developed, small, better sclerotized at posterior edge around phallus. Phallus (= aedeagus of authors, but see Kristensen, 2003) narrow, with shaft flattened dorsoventrally beyond middle, better sclerotized on left side in narrow band, slightly upturned apically; coecum penis medium-sized with pair of very small peduncles laterally; vesica with minute scobination.

Female genitalia (Fig. 5). Papillae anales large and long, moderately setose, sclerotized dorsally and laterally at base. Posterior apophyses slightly curved apically, slightly longer than papillae. Tergum VIII well sclerotized, with few long setae especially on margin, with deep rounded concavity in middle apically; middle of concavity with posteriorly directed projection variable in length and bearing two setae. Anterior apophyses straight, slightly enlarged apically, about as long as papillae. Sternum VIII with apical margin bell shaped, well sclerotized, with few long setae mostly posteriorly along margin and midventrally. Intersegmental membrane between sternites VII and VIII slightly sclerotized on each side of midventral line and with pair of short projections inside body at apical margin. Ostium bursae in middle of sternite VIII, ventrally protected by slightly protruding crescent of sclerotization. Ductus bursae short, gradually enlarging, basal half well sclerotized, distal half spiculose and with wrinkles patterned like brood cells in bee hive. Corpus bursae slightly longer than wide, spiculose, with one large, spiny, curved, and pointed cornutus; latter set in small sclerotized patch with pair of bumps on each side of its base.

DESCRIPTION OF THE LARVA AND PUPA: Larva. (Figs 7-17): Length 5.0-8.2 mm ( $n = 72$ ), < 5.0 mm ( $n = 94$ ). Body pale gray, textured with microconvolutions; head capsule amber; prothoracic shield amber, gradually darkening posteriorly; pinacula pale brown; anal plate pale amber; setae with widened, circular, and slightly raised



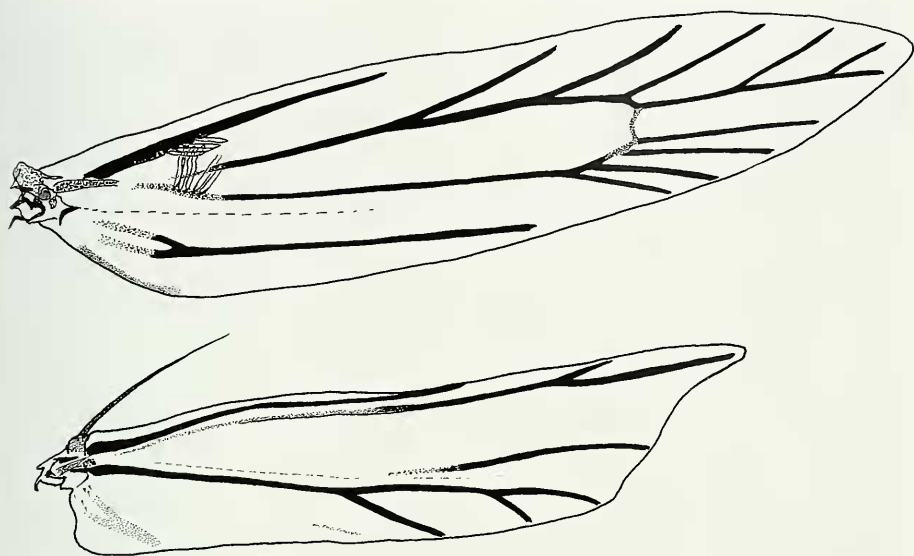
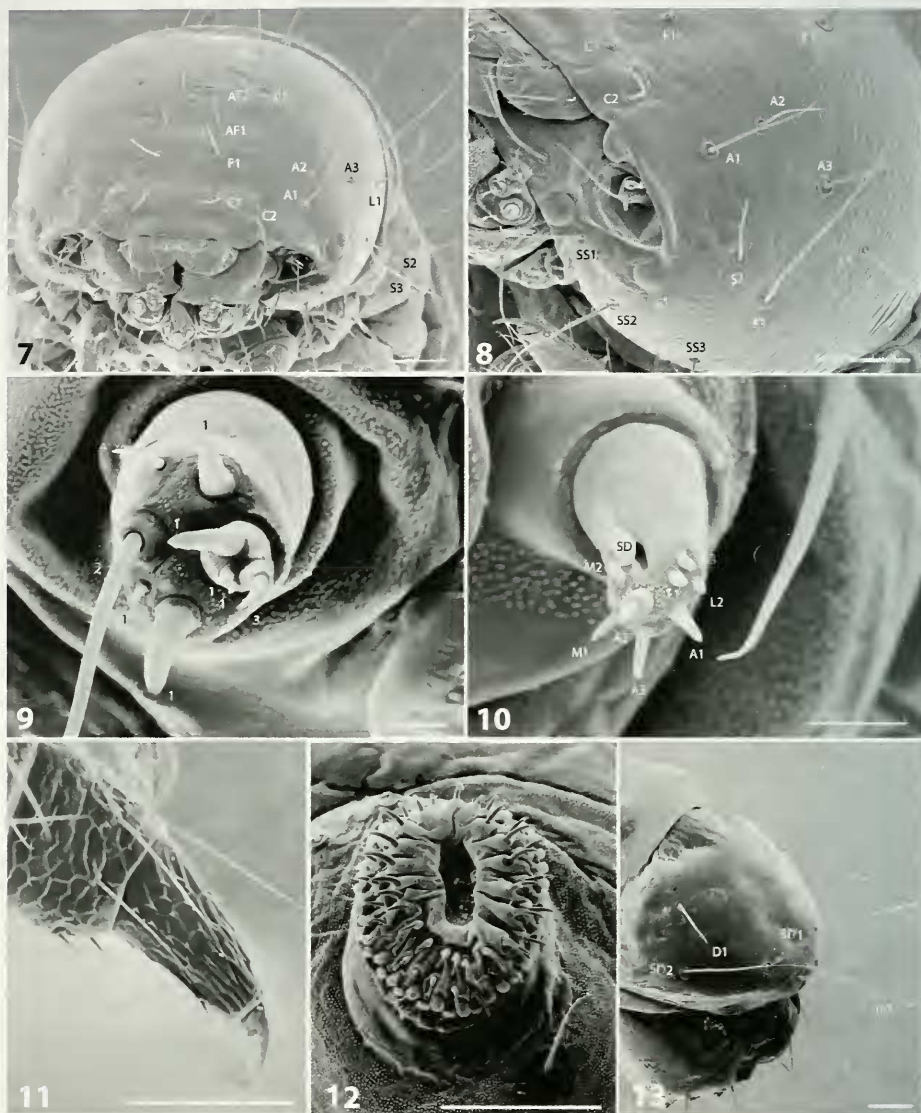


FIG. 6

Wing venation of *Taygete sphecophila*.

sockets. Head (Figs 7-10, 17): hypognathous, textured with slightly raised, confluent, polygonal ridges except on area between adfrontal sclerites (Figs 7-8); adfrontal sclerites widened distally, frontal setae about equal in length, AF2 above apex of frons, AF1 below; F1 slightly closer to AF1 than to C1; C2 at least 2 1/2 times longer than C1; clypeus with 6 pairs of setae, 3 pairs on medial half, 3 on distal half; mandible angular (Fig. 17), shallowly notched subapically forming small apical dentition, bearing pair of subequal setae on outer surface near condyle, and with 1 large dentition on inner surface; sensilla types and arrangement on antenna (Fig. 9) and on maxillary palpi (Fig. 10) similar to those of other Gelechioidea studied by Adamski & Brown (1987), Adamski (1999), Adamski & Pellmyr (2003), Landry & Adamski (2004), and Wagner *et al.* (2004), and other Lepidoptera studied by Adamski & Brown (2001), Albert (1980), Avé (1981), Grimes & Neunzig (1986a, b), and Schoonhoven & Dethier (1966). Three stemmata in genal area, 1 approximate pair above antenna, and 1 stemma below antenna; substemmatal setae about equal in length, arranged as in Fig. 8; S3 and S1 elongate and about equal in length, S2 short; S3 lateroventral to S2, S2 approximate to stemma 3, and S1 approximate to stemma 5 (stemmata 1, 2, and 6 absent); A-group setae above gena, mesal to L1; P1 dorsolateral to AF2, P2 dorsomesal to P1. Thorax (Figs 11, 14): T1 with L-group trisetose, on large pinaculum extending beneath and posterior of spiracle; setae anterior to spiracle; L1 approximate and posteroventral to L2, about 2 1/2 times lengths of L2 and L3; SV-group setae on anterior part of elongate pinaculum; SV1 about 1/3 longer than SV2; coxae nearly touching, V1s very approximate (not shown); segments of leg textured with slightly elongate ridges, many produced distally into hairlike spines, claw single (Fig. 11); shield with SD1 slightly posterior to and about 1/3 longer than XD2 and XD1; XD2, XD1, D1, and SD2 about



FIGS 7-13

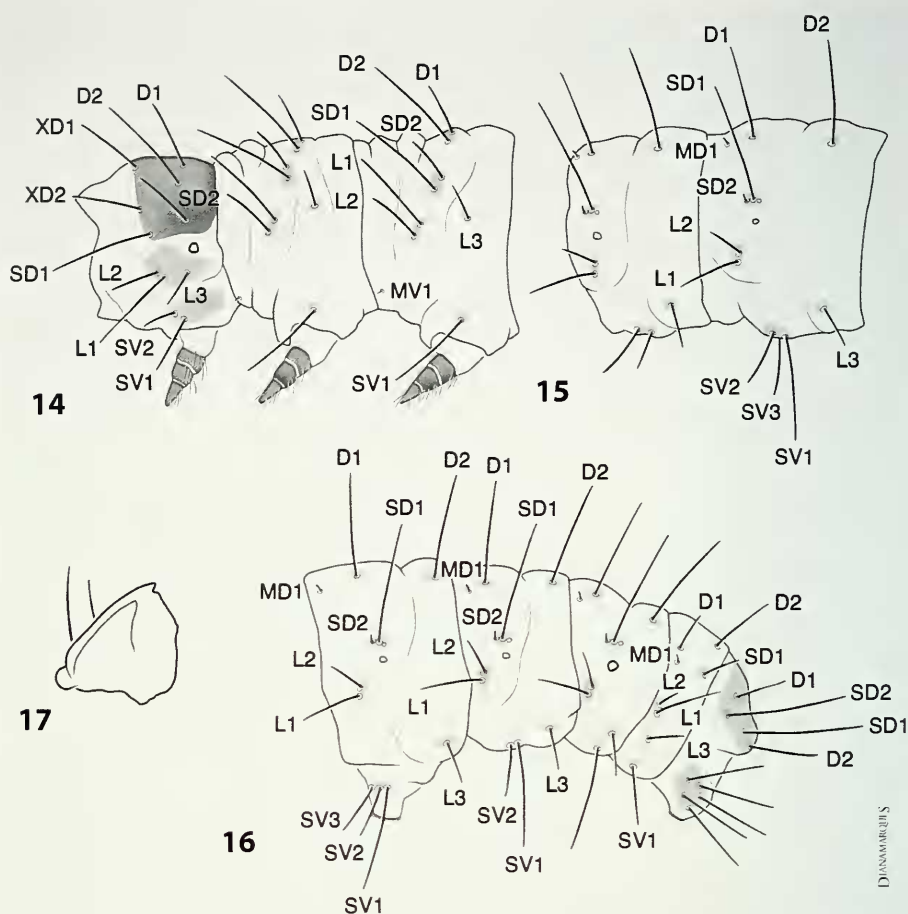
Scanning electron micrographs of larva of *Taygete sphecephila*. 7, Frontolateral view of head capsule, scale = 100  $\mu$ ; 8, Ventrolateral view of head capsule, scale = 100  $\mu$ ; 9, Sensilla of antenna: 1 = sensilla basiconica, 2 = sensillum chaetica, 3 = sensillum styloconicum, 4 = sensillum trichodeum, scale = 10  $\mu$ ; 10, Sensilla of maxillary palpus: A2 = sensillum styloconicum, A1, A3, M1-2, L1-3 = sensilla basiconica, SD = sensillum digitiform, scale = 10  $\mu$ ; 11, Distal portion of left prothoracic leg showing claw, scale = 10  $\mu$ ; 12, Left proleg on A4, scale = 100  $\mu$ ; 13, Anal plate of A10, scale = 100  $\mu$ .

equal in lengths, XD2 about twice distance from XD1 than from SD1; D1 in straight line with XD1, slightly posterior to SD2 and D2; D2 about same length as SD1, in straight line with SD2. T2-T3 (Fig. 14): D2 about 2 times length of D1, both on small pinaculum; SD1 about 2 times length of SD2, both on small pinaculum; L1 about 1/3 longer than L2, both on small pinaculum, L3 slightly shorter than L2, posterior to or in vertical line with SV1; MV1 on anterior margin between T2-T3, slightly above SV1 (hard to see); V1s on T2-T3 about equal distance apart, at least 4 times distance between V1s on T1. Abdomen (Figs 12, 13, 15, 16): A1-A2 (Fig. 15): D2 and D1 equal in lengths or D2 slightly longer, MD1 on anterior part of segment anteroventral to D1; SD1 above spiracle, about 1/3 longer than D2, with minute SD2 (anterior part of pinaculum); small opening on ventroposterior margin of pinaculum bearing SD1 and SD2; spiracle on A1 slightly larger than those on A2-A7; L1 2 times length of L2, both on same pinaculum, slightly anterior of spiracle; L3 about same length as L2, anterior to, in vertical line with, or posterior to D2; SV-group bisetose on A1, trisetose on A2, on same pinaculum; V1s equal distance apart (not shown). A3-A10 (Figs 12, 13, 16): A3-A6 with 4 pairs of protuberant prolegs, crochets biordinal, in circle (Fig. 12); setae as above; A7 as above except, SV-group bisetose and on same pinaculum; A8 as above except with spiracle slightly larger than on previous segments and SV-group unisetose; A9 with D2 about 2-2 1/2 times longer than D1; D1 anterior to D2 and SD1, equidistant to both setae; SD1 about same length as D1; L-group setae slightly anterior to D1; L1 about 3 times length of L2, on same pinaculum; L3 slightly longer than L2; SV1 slightly shorter than L1; V1s as previous segments; A10 (Figs 13, 16): anal plate with SD2 and SD1 equal in lengths, about twice length of D2; D1 slightly shorter than D2; crochets of proleg biordinal, in semicircle, gradually shortened mesally and laterally.

Pupa. (Figs 18-21): Length 3.6-4.6 (n = 10): amber, smooth, spiracles protuberant; all dorsal setae apically hooked except long seta associated with axillary tubercle (Figs 19-20). Sclerites of antennae annulated, widely separated anteriorly, gradually convergent from beyond basal 1/3 of sclerites of maxillae, fused for short distance beyond distal apices of sclerites of maxillae, gradually divergent posteriorly, exposing distal part of sclerites of hindlegs; sclerites of midleg not fused distally; paired nodular scars of prolegs on A5-A6 (Fig. 18); A6-A10 fused, rotating as unit; cremaster dorsolaterally flattened, trapezoidal basally, extending posterolaterally into 2 slightly divergent and elongate spine-like processes (Fig. 21).

DISTRIBUTION AND PHENOLOGY: The species was described from Trinidad (Meyrick, 1936) and never mentioned from anywhere else subsequently. In the Galapagos Islands it has been found on Floreana (from the littoral to the humid zones), San Cristobal (in the arid zone), and Santa Cruz (from the littoral to the humid zones). In the Galapagos we have collected live moths of this species in January, February, March, April, September, November, and December.

NOTES: Preliminary phylogenetic analyses, both morphological and molecular, support the placement of *Taygete sphecophila* within Autostichidae (PS, unpublished data). For example, Kaila's (2004) matrix was reanalyzed with *T. sphecophila* data, and the species clusters in Kaila's autostichid assemblage with *Galagete* Landry.



FIGS 14-17

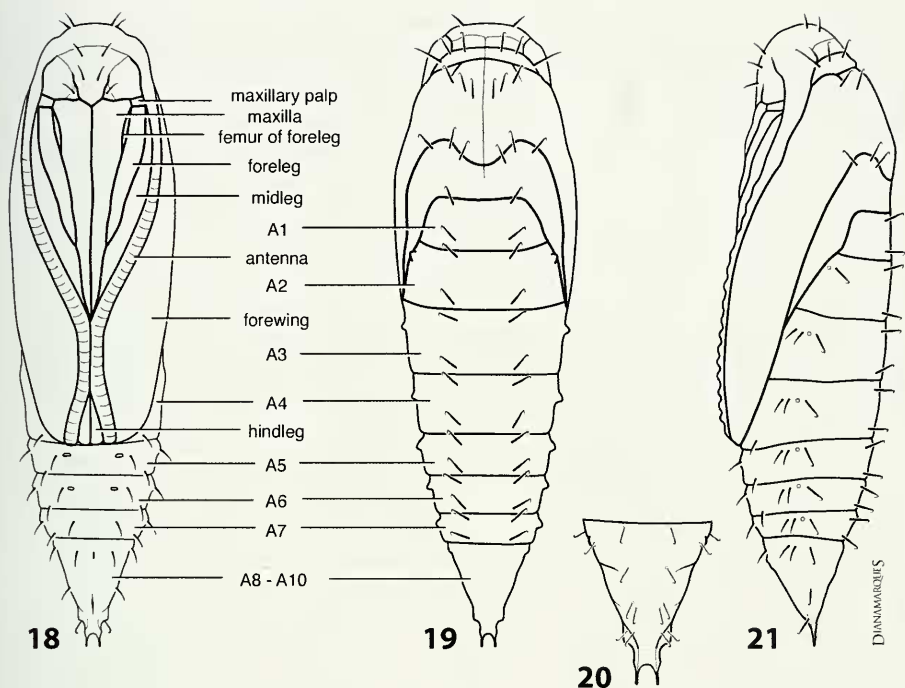
Larva of *Taygete sphecophila*. 14, Chaetotaxy of thorax; 15, Chaetotaxy of abdominal segments 1-2; 16, Chaetotaxy of abdominal segments 6-10; 17, Mandible.

A comparison of a 1283 base pairs fragment (consisting of most of the COI gene except the first 254 base pairs) sequenced for a larva and an adult of *Taygete sphecophila* showed no substitution, which clearly indicates conspecificity.

The larva has only three stemmata, a condition that is highly unusual in Gelechioidea and that may be due to the unique host relationship.

It proved impossible to evaginate the ventro-abdominal pouch (Fig. 4) in several male specimens of this species. However, BL was able to evaginate this core-matal organ from a specimen of *Taygete attributella* (Walker). The organ consists of a narrow membranous tube, almost as long as the abdomen, on which narrow scales are connected all around. The membrane of the tube is very thin and the tube collapsed as soon as specimens were transferred to lactic acid for temporary storage. An illustration of this structure for the closely related *Galagete turritella* Landry is provided by Landry (2002: Figs 17, 18).





FIGS 18-21

Pupa of *Taygete sphecophila*. 18, Ventral view; 19, Dorsal view; 20, Segments 8-10; 21, Lateral view.

## ECOLOGICAL STUDY

### PATTERNS OF PREDATION

Although egg-laying was never observed, it is possible that the female moths lay their eggs within the pupal cells of *P. versicolor* through numerous small holes of 1-2 mm in diameter that we observed on the back of the nests. In a sample of 25 *P. versicolor* nests, the number of *T. sphecophila* moths found per nest varied between 3 and 13. However, 42 *T. sphecophila* larvae were recovered by PS from a rather small nest collected on Santa Cruz in 2004. The food source needed for the development of the moth's larvae are the wasps' pupae which are defenseless because of their isolation in their capped cells. When ready to emerge from the wasp's cell, the moth makes a distinctive breach through the cap covering the top of the cell.

### DISTRIBUTION OF INFESTED NESTS

The level of *T. sphecophila* infestation could only be assessed for nests of *P. versicolor* that were abandoned. A total of 103 such nests were found on the different study sites on Santa Cruz Island between 1999 and 2003, and 141 nests on Floreana Island in 1999. The percentages of nests that presented signs of predation by *T. sphecophila* are given in Table 1, along with the vegetation zones in which they were found.

TABLE 1. Percentage of *Polistes versicolor* nests found in four different vegetation zones of Santa Cruz and Floreana Islands presenting signs of *Taygete sphecophila* predation. Number of nests per sample are in parentheses.

Vegetation Zone	% of nests with <i>T. sphecophila</i> predation	
	Santa Cruz Island	Floreana Island
Littoral	35.3 (n=17)	40.0 (n=5)
Arid	43.0 (n=79)	13.9 (n=101)
Transition	20.0 (n=5)	66.7 (n=6)
Humid	100.0 (n=2)	51.7 (n=29)

On Santa Cruz island the arid zone was the area of highest abundance of nests. This result is similar to that obtained by Roque-Albelo & Causton (1999) for abundance of adult foragers. The percentages of infestation varied between zones (Table 1). However, very few nests were collected in the littoral, transition, and humid zones. Nests of *P. versicolor* were again more common in the arid zone of Floreana. However, only 13.9% of them were infested by *T. sphecophila* in this zone. In contrast to Santa Cruz, on Floreana nests also were abundant in the humid zone, where 51.7 % of them were infested.

The results of the G-test for goodness of fit allow us to test for ecological trend in nest infestation according to vegetation zonation. The proportion of parasitism in *Polistes versicolor* nests in the four vegetation zones on Santa Cruz Island does not show deviation from the expected (based on the proportion of *P. versicolor* nests found in each vegetation zone;  $G = 4.806$ ,  $df = 3$ ,  $P > 0.05$ ). However, the situation on Floreana Island appears different as *P. versicolor* nests found in the arid zone are infested by *T. sphecophila* less than expected, and nests found in the transition and humid zones are infested more than expected ( $G = 15.482$ ,  $df = 3$ ,  $P < 0.01$ ).

## DISCUSSION

Different factors, including climatic conditions, infestation by nest scavengers and parasitoids, and predation affect the wasp colony cycle (Yamane, 1996). Across its range of distribution, from Costa Rica to Southern Argentina, *P. versicolor* seems to prefer dry forest habitats (Richards, 1978). Data from previous studies suggest that in the Galapagos the wasps are more abundant in the arid zone of the islands (Roque-Albelo & Causton, 1999; Lasso, 1997). This preference in distribution could be associated with climatic conditions (Parent, 2000). In the Galapagos the higher zones of the islands are cooler and receive more rainfall than lower zones, particularly on the southern slopes, and this factor probably affects nest development. Collection data of *T. sphecophila* suggest a similar pattern of distribution. Most moth specimens were collected in the dryer zones of the islands suggesting a close correlation with nest abundance.

On Santa Cruz Island the occurrence of *T. sphecophila* in different vegetation zones is a reflection of the frequency of *P. versicolor* nests. However, *T. sphecophila* seems to be more abundant than expected in the transition and humid zones of Floreana Island and less frequent in the arid zone. Therefore, *T. sphecophila*'s occurrence on Floreana Island is not strictly a reflection of the abundance of *P. versicolor* nests,

suggesting that other ecological or climatic factors might influence its distribution. It is not clear why there is such a difference between Floreana and Santa Cruz islands, but one possible hypothesis is that *T. sphecophila* has colonized these two islands at different points in time, so that populations on one of the island have had more time to adapt to the island's ecological and climatic context.

*Polistes* nests, as in many other social wasps, are scavenged and parasitized by various insects including more than 11 moth species from four families (Makino, 1985). Only *Taygete sphecophila* was found in the Galapagos, where the species apparently prefers to attack large nests, and all infested nests collected were large enough to presume that they were in an advanced stage of the reproductive phase. If predation by *T. sphecophila* is restricted to this stage of the wasp colonies the probabilities for this moth species to be an effective agent of biological control are reduced. These results support the idea of Miyano (1980) that parasitic and scavenging Lepidoptera reduce notably the colony's productivity but are not thought to be a direct cause of colony failure. However, the possibility to use *T. sphecophila* as a biological control agent against *P. versicolor* needs to be evaluated.

We believe that the first individuals of *Taygete sphecophila* probably arrived within a nest of *P. versicolor* built on some human-made structure that would have traveled by boat from the continent. It is actually quite possible that both animals arrived together on the Galapagos. The wasp was first detected in 1988 on Floreana, and is thought to have arrived with a shipment of bananas (Abedrabbo, 1991), but Eduardo Vilema, resident of Santa Cruz, says that he first saw a nest of *Polistes versicolor* near Bella Vista, on Santa Cruz, in 1984 or 1985 (pers. comm. to BL in 2004). And we think it unlikely that the wasps came on banana regimes as they are not known to build their nests there.

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